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EFFECT OF GARLIC ON THE FLAVOR AND ODOR OF MILK

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OBJECT OF THE EXPERIMENT

When dairy cows are first turned out on pasture in the early spring there is probably no plant which more seriously affects the flavor and odor of milk than garlic, or wild onion. In some sections it renders the milk practically unmarketable. Once the garlic flavor and odor have entered the milk there is no efficient or economical method known of eliminating it. The only practical way to prevent the presence of garlic flavor and odor in milk appears to be by preventing the cows from eating the plant.

In order to obtain more definite information concerning the effect of garlic on the flavor and odor of milk, feeding experiments were conducted by the Bureau of Dairying on its experiment farm at Beltsville, Md.[1] The specific objects of the investigation were: (1) To determine how garlic flavor and odor enter the milk; (2) to determine the length of time required after consumption of garlic for the flavor and odor to enter the milk; (3) to determine the length of time after cows consume garlic before the flavor and odor disappear from the milk.

Note.—The writer acknowledges the assistance of T. E. Woodward, in charge of the dairy experiment farm, Beltsville, Md., who supervised the experimental work at the farm.

[1] The effects of silage, green alfalfa, green corn, turnips, cabbage, and potatoes have been studied and reported in Department of Agriculture Bulletin No. 1097, The Effect of Silage on the Flavor and Odor of Milk; Department Bulletin No. 1190, The Effect of Feeding Green Alfalfa and Green Corn on the Flavor and Odor of Milk; Department Bulletin No. 1208, Effect of Feeding Turnips on the Flavor and Odor of Milk; and Department Bulletin No. 1297, Effect of Feeding Cabbage and Potatoes on the Flavor and Odor of Milk.

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DETAILS OF EXPERIMENT

The investigation was conducted with nine Jersey and seven Holstein cows. The cows were giving milk relatively free from abnormal flavors and odors, and entirely free from garlic flavor and odor when fed the basic hay and grain ration. The average daily milk production of the cows during the investigation was 31.5 pounds, the highest daily average being 44 pounds, the lowest 16 pounds.

The garlic fed was of the variety commonly found growing wild. Only the garlic tops were fed, and at the time of feeding were about 10 or 12 inches high. They were cut into short lengths and mixed with ground feed, in order that the cows would readily consume the garlic.

Samples were taken from the milk of each cow at the time of milking, given a key number and cooled, but not aerated. The samples were judged for flavor and odor by experienced judges, who had no knowledge of the key. An "opinion," as this term is used in this bulletin, denotes the decision of the judge in regard to one sample.

Using the term "garlic" to signify flavors and odors which the judges believed to be due to garlic, the following classification was used: Normal, very slight garlic, slight garlic, and strong garlic. When no garlic flavor or odor was perceptible the sample was rated normal, and when a garlic flavor or odor was perceived the sample was rated according to the degree in which the judge considered garlic to be present.

MILK TESTS

CHECK SAMPLES

The check samples were taken from milk produced by cows which were fed no garlic. At the beginning of the investigation some garlic flavor and odor were perceived in these samples. A total of 180 opinions on 26 samples showed only 78.9 per cent rating the milk normal in flavor, and 77.8 per cent normal in odor. Although the larger percentage of the cases of garlic flavor and odor were rated very slight garlic, some were rated slight garlic and strong garlic. (See Table 1, group 1, and fig. 1, A.)

Investigation as to the cause of garlic flavor and odor in the check samples showed that at least five of these samples were produced by cows which inhaled some garlic odor as they were standing by the side of cows consuming garlic. The opinions on these five samples showed only 36.8 per cent rating the milk normal in flavor and 34.2 per cent rating the milk normal in odor. Opinions were equally divided between very slight garlic and slight garlic; 23.7 per cent representing flavor and 26.3 per cent representing odor in each of these groups, whereas 15.8 per cent rated the flavor and 13.2 per cent rated the odor strong garlic. (See Table 1, group 2, and fig. 1, B.)

After eliminating the five samples from cows standing by the side of those consuming garlic, the remaining check samples still showed a few cases of garlic flavor and odor which also were probably due to the inhalation of garlic odor. However, 90.2 per cent of the opinions rated these samples normal in flavor and 89.5 per cent normal in odor. Of the opinions designating garlic flavor and

odor, 5.6 per cent rated the flavor and 6.3 per cent rated the odor very slight garlic, whereas 4.2 per cent of the opinions rated the samples slight garlic in both flavor and odor. None of the opinions rated a sample as strong garlic in either flavor or odor. (See Table 1, group 3, and fig. 1, C.)

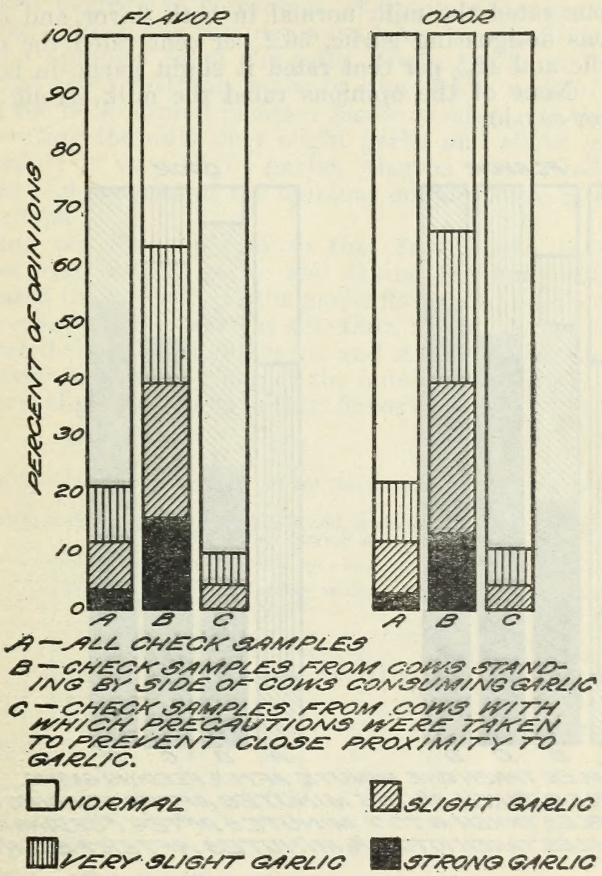

FIG. 1.—Check samples

TABLE 1.—*Flavor and odor found in check samples of milk*

[Group 1: All check samples taken during experiment. Group 2: Check samples produced by cows standing by the side of cows consuming garlic during milking. Group 3: Check samples produced by cows with which precautions were taken to prevent close proximity to garlic]

Rating	Percentage of opinions					
	Flavor			Odor		
	Group 1	Group 2	Group 3	Group 1	Group 2	Group 3
Normal	78.9	36.8	90.2	77.8	34.2	89.5
Very slight garlic	9.5	23.7	5.6	10.5	26.3	6.3
Slight garlic	8.3	23.7	4.2	8.9	26.3	4.2
Strong garlic	3.3	15.8	0	2.8	13.2	0
Total	100.0	100.0	100.0	100.0	100.0	100.0

TIME REQUIRED FOR GARLIC FLAVOR AND ODOR TO ENTER MILK

In order to determine the time required for garlic flavor and odor to enter milk, cows were fed one-half pound of garlic, and samples of milk were taken at various intervals after feeding. When the samples were taken one minute after feeding, 31.3 per cent of the opinions rated the milk normal in both flavor and odor. Of the opinions designating garlic, 56.2 per cent rated the milk very slight garlic and 12.5 per cent rated it slight garlic in both flavor and odor. None of the opinions rated the milk strong garlic in either flavor or odor.

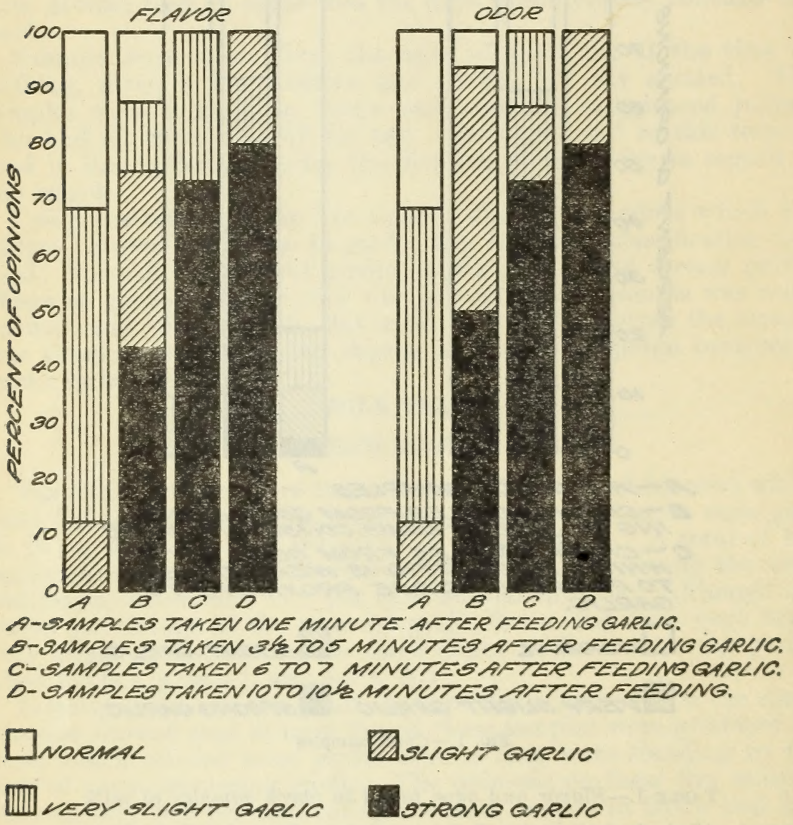

FIG. 2.—Time required after consumption of garlic for garlic flavor and odor to enter the milk.

Increasing the time interval between feeding and taking the milk samples from one minute to from three and one-half to five minutes, increased the percentage of opinions designating garlic in the samples. When the samples were taken at this time only 12.5 and 6.3 per cent of the opinions rated the milk normal in flavor and odor, respectively. Of the opinions designating garlic flavor and odor, those rating the samples as strong garlic showed the higher percentage, 43.7 per cent representing flavor and 50 per cent representing odor in this group; whereas 12.5 and 31.3 per cent of

the opinions rated the flavor very slight garlic and slight garlic, respectively, and 43.7 per cent rated the odor as slight garlic, none of the opinions rating the odor very slight garlic.

A further increase in the time interval between feeding the garlic and taking the milk samples to from six to seven minutes increased to a marked degree the percentage of opinions designating garlic in the milk. When the samples were taken at this time, 73.3 per cent of the opinions rated the milk strong garlic in flavor, and 73.4 per cent rated it strong garlic in odor, while none of the opinions rated the milk normal in either flavor or odor. Of the opinions on flavor rating the milk very slight garlic and slight garlic, 26.7 per cent rated it very slight garlic, whereas none rated it slight garlic; and 13.3 per cent of the opinions on odor were rated in each of these groups.

Increasing the time interval so that from 10 to 10½ minutes elapsed between feeding garlic and taking the milk samples further increased the intensity of the garlic flavor and odor in the milk. When the samples were taken at this time, 20 and 80 per cent of the opinions rated the milk slight garlic and strong garlic, respectively, in both flavor and odor. None of the opinions rated a sample normal or very slight garlic in either flavor or odor. (See Table 2 and fig. 2.)

TABLE 2.—*Time required for garlic flavor and odor to enter milk*

[Percentage of opinions detecting garlic in samples of milk produced by cows consuming one-half pound of garlic at various intervals after feeding]

Rating	Flavor—Time interval between feeding and taking milk sample				Odor—Time interval between feeding and taking milk sample			
	1 minute	3½ to 5 minutes	6 to 7 minutes	10 to 10½ minutes	1 minute	3½ to 5 minutes	6 to 7 minutes	10 to 10½ minutes
	Per cent	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*
Normal	31.3	12.5	0	0	31.3	6.3	0	0
Very slight garlic	56.2	12.5	26.7	0	56.2	0	13.3	0
Slight garlic	12.5	31.3	0	20.0	12.5	43.7	13.3	20.0
Strong garlic	0	43.7	73.3	80.0	0	50.0	73.4	80.0
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

TIME REQUIRED AFTER CONSUMPTION OF GARLIC FOR THE MILK TO BE FREE FROM GARLIC FLAVOR AND ODOR

In order to determine how long after dairy cows have consumed garlic the flavor and odor produced by this plant continue to be perceptible in the milk, cows were fed one-half pound of garlic at various intervals before milking.

Feeding this amount of garlic four hours before milking showed that the garlic flavor and odor were still present to a very marked degree, 71.4 per cent of the opinions rating the milk strong garlic in both flavor and odor. The garlic odor was slightly more pronounced than the garlic flavor, 7.2 and 21.4 per cent rating the odor very slight garlic and slight garlic, respectively, whereas 14.3 per cent of the opinions rated the flavor in each of these groups. None of the opinions rated the milk normal in either flavor or odor.

When the garlic was fed five hours before milking there was a slight decrease in the intensity of the garlic flavor and odor in the milk as compared with feeding four hours before milking. When the garlic was fed at this time 7.1 per cent of the opinions rated the milk normal in both flavor and odor. Of the opinions designating garlic, 28.6 and 64.3 per cent rated the flavor slight garlic and strong garlic, respectively, while 21.5 and 71.4 per cent gave similar ratings to the odor.

Increasing the time between garlic feeding and milking from five to six hours decreased to a marked extent the intensity of the garlic flavor and odor in the milk. When fed at this time 30 per cent of

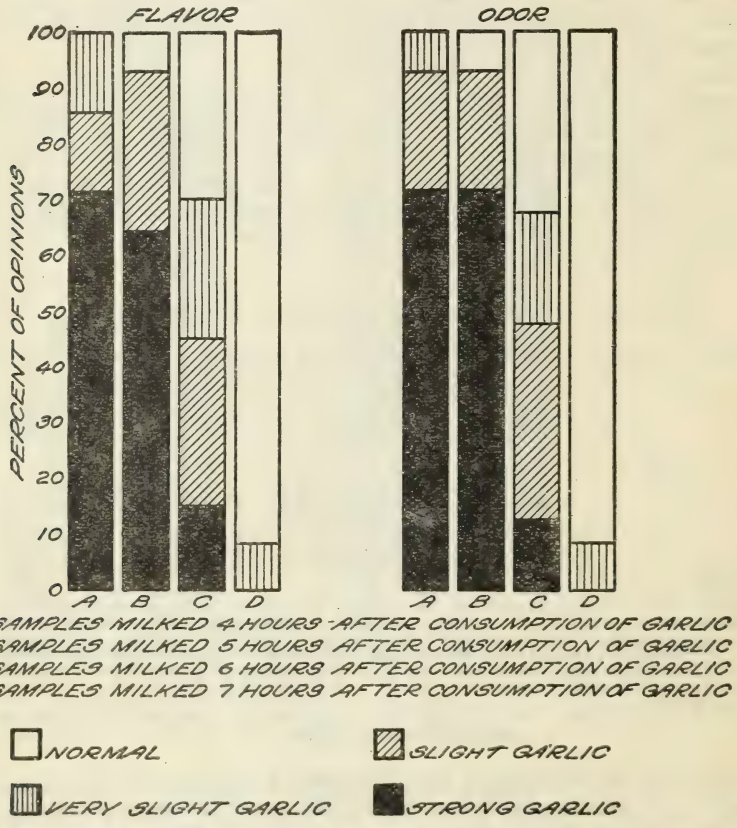

FIG. 3.—Time required after the consumption of garlic for the milk to be free from garlic flavor and odor

the opinions rated the milk normal in flavor and 32.5 per cent rated it normal in odor. Garlic flavor and odor, however, were still present to a considerable extent, 15 per cent of the opinions rating the flavor and 12.5 per cent rating the odor strong garlic, whereas 25 and 30 per cent rated the flavor very slight garlic and slight garlic, respectively, and 20 and 35 per cent gave similar ratings to the odor.

Increasing the time interval so that seven hours elapsed between garlic feeding and milking, practically eliminated the garlic flavor

and odor from the milk. When fed at this time, 91.7 per cent of the opinions rated the milk normal in both flavor and odor. All of the garlic flavors and odors, i. e., 8.3 per cent of the opinions, were rated as very slight garlic. (See Table 3 and fig. 3.)

TABLE 3.—*Time required after the consumption of garlic for the milk to be free from garlic flavor and odor*

[Percentage of opinions detecting garlic in samples of milk produced by cows consuming one-half pound of garlic at various intervals before milking]

Rating	Flavor—Time interval between feeding and milking				Odor—Time interval between feeding and milking			
	4 hours	5 hours	6 hours	7 hours	4 hours	5 hours	6 hours	7 hours
	Per cent	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*
Normal	0	7.1	30.0	91.7	0	7.1	32.5	91.7
Very slight garlic	14.3	0	25.0	8.3	7.2	0	20.0	8.3
Slight garlic	14.3	28.6	30.0	0	21.4	21.5	35.0	0
Strong garlic	71.4	64.3	15.0	0	71.4	71.4	12.5	0
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

INHALATION OF GARLIC

The presence of garlic flavor and odor in the check samples, and the shortness of the time after feeding garlic before the flavor and odor were perceptible in the milk, indicate that it was not necessary for garlic to be taken into the stomach of the cow before entering the blood stream and thence passing to the udder. The only other way that garlic flavor and odor could enter the milk would be by the odor being inhaled, then absorbed by the blood in the lungs, and so transmitted to the milk. In order to determine whether this actually took place, cows were forced to inhale garlic odor for 10 minutes and were then milked at varying intervals after inhalation. The inhalation took place in such a manner that there was no possible chance for the cows to consume any of the garlic, and outside of the milking barn in order that there should be no chance of a garlic-permeated atmosphere surrounding the milk. Therefore, any garlic flavor or odor perceptible in the milk would of necessity come by absorption from the lungs into the blood stream and thence to the udder.

When the cows were milked two minutes after inhaling garlic for 10 minutes (or 12 minutes after they began to inhale garlic), the garlic flavor and odor were very pronounced in the milk. The larger percentage of opinions—i. e., 87.5 per cent—rated the flavor of the milk strong garlic, whereas 12.5 per cent rated it slight garlic. There were no opinions rating the flavor either normal or very slight garlic. The garlic odor was even more pronounced than the garlic flavor, 100 per cent of the opinions rating the odor of the milk strong garlic.

Having determined that the garlic flavor and odor enter the milk by inhalation, in order to further determine the length of time after inhalation that the flavor and odor continue perceptible in the milk, the time interval between inhalation and milking was increased to 30 minutes. When the samples were taken at this time, the garlic flavor and odor, although not so intense as after the two-minute

interval, were present to a marked degree, 14.3 per cent of the opinions rating the milk normal, and 42.9 per cent rating it strong garlic in both flavor and odor. Opinions were equally divided between very slight garlic and slight garlic, 21.4 per cent being in each of these groups for both flavor and odor.

Increasing the time interval between the inhalation and milking from 30 minutes to 60 minutes, decreased to a considerable degree the intensity of the garlic flavor and odor in the milk. When the samples were taken at this time, as many opinions rated the milk

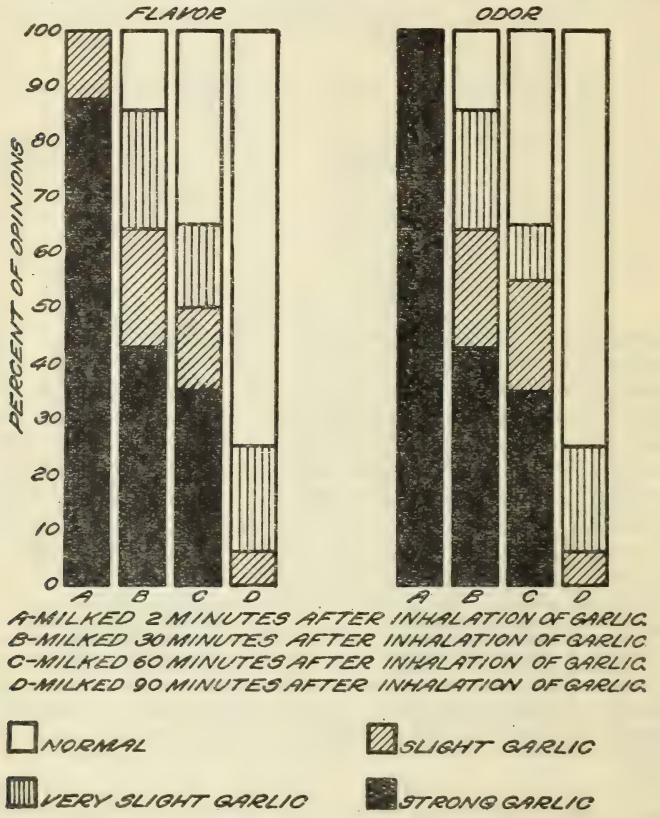

FIG. 4.—Effect of inhalation of garlic on the flavor and odor of milk

normal as rated it strong garlic in both flavor and odor, i. e., 35 per cent. Of the opinions rating the milk very slight garlic and slight garlic, 15 per cent rated the flavor in each of these groups, whereas in odor 10 per cent rated it very slight garlic and 20 per cent rated it slight garlic.

When the time interval was further increased so that 90 minutes elapsed between the inhalation of garlic and milking, the greater part of the garlic flavor and odor was eliminated. When the samples were taken at this time 75 per cent of the opinions rated the milk normal in both flavor and odor. Of the opinions rating the milk very slight and slight garlic, 18.8 per cent rated it very slight

garlic, whereas only 6.2 per cent rated it slight garlic in both flavor and odor. There were no opinions rating the milk strong garlic in either flavor or odor. (See Table 4 and fig. 4.)

TABLE 4.—*Effect of inhalation of garlic upon flavor and odor of milk*

[Percentage of opinions detecting garlic in samples of milk produced by cows inhaling garlic for 10 minutes at various intervals before milking]

Rating	Flavor—Time interval between inhalation amd milking				Odor—Time interval between inhalation and milking			
	2 minutes	30 minutes	60 minutes	90 minutes	2 minutes	30 minutes	60 minutes	90 minutes
	Per cent	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*
Normal	0	14.3	35.0	75.0	0	14.3	35.0	75.0
Very slight garlic	0	21.4	15.0	18.8	0	21.4	10.0	18.8
Slight garlic	12.5	21.4	15.0	6.2	0	21.4	20.0	6.2
Strong garlic	87.5	42.9	35.0	0	100.0	42.9	35.0	0
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

BLOOD TESTS

In order for flavors and odors to enter the milk through the body of the cow, it is necessary for these flavors and odors to be absorbed by the blood stream and then transmitted to the udder. To determine whether garlic could be detected in the blood, cows were fed two pounds of garlic tops, and blood samples were taken from the jugular vein 16 minutes, 30 minutes, and 45 minutes after feeding. The blood was examined approximately 24 hours after the samples were drawn, coagulation being prevented by the addition of sodium citrate.

The sample drawn 16 minutes after feeding was rated "not perceptible," as the judges failed to identify a garlic odor. The sample drawn 30 minutes after feeding showed the garlic odor to such an extent that the judges readily identified it, while the sample drawn at 45 minutes after feeding gave off a strong odor of garlic.

A comparison of these blood tests with the milk tests shows what appears to be a discrepancy, as it required a greater lapse of time between feeding the garlic and taking the samples for the garlic to be perceived in the blood than in the milk. This may be due to one or more causes. The garlic flavor and odor may have an affinity for fat and, therefore, pass rapidly from the blood to the milk. It may also be that garlic is more easily perceived in milk than in blood.

CONCLUSIONS

Garlic flavor and odor were detected in the milk when the milk samples were taken one minute after feeding garlic.

The intensity of the garlic flavor and odor increased as the time interval between feeding the garlic and taking the milk samples increased, until at 10 minutes a high degree of intensity was reached.

Garlic flavor and odor were present in milk to a very objectionable degree when the cows consumed one-half pound of garlic four hours before milking.

As the time interval between garlic consumption and milking increased, the intensity of the garlic flavor and odor in the milk decreased, and at seven hours had practically disappeared.

Strong garlic flavor and odor were found in milk drawn two minutes after the cows inhaled garlic for 10 minutes.

As the time interval between the inhalation of garlic and milking increased, the intensity of the garlic flavor and odor in the milk decreased, and they practically disappeared in 90 minutes.

Garlic odor was readily perceived in samples of blood drawn 30 minutes after feeding the cows two pounds of garlic tops, and strong garlic odor was present in the blood drawn 45 minutes after such feeding.

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